Natural Conditions Assessment for Low Dissolved Oxygen and pH, Thompson Branch and Tributaries in Westmoreland County, Virginia

Submitted by
Virginia Department of Environmental Quality

September 2013

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Executive Summary

This report presents the assessment of whether low pH and dissolved oxygen (DO) in Thompson Creek and tributaries are due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Thompson Creek is located within Westmoreland County, Virginia, and is a minor tributary of Lower Machodoc Creek, which is a tributary of the Potomac River. The waterbody identification (WBID) code for Thompson Creek is VAP-A32R. Thompson Creek encompasses a total of approximately 3.91 rivermiles (National Hydrography Dataset (NHD). Thompson Creek and tributaries were listed as impaired due to violations in water quality standards for DO and pH. This report addresses both the DO and pH impairments.

The total area of the Thompson Branch and tributaries watershed is approximately 1817 acres (2.84 square miles). The average annual rainfall is 42.53 inches. The watershed is predominately wetlands (32 percent) and forested (30.0 percent). Agriculture (hay/pasture 8 percent and cropland 22 percent) comprises 30 percent of the watershed. Urban areas compose approximately 6 percent of the land base. The remaining 2 percent of the watershed is comprised of other grasses. Land use was not considered to have significantly impacted the swampwater conditions of Thompson Branch and tributaries.

The mainstem of nontidal Thompson Creek was listed as impaired on Virginia's 2006, 2008, 2010 and 2012 305(b) / 303(d) Integrated Reports (VADEQ, 2006, 2008, 2010 and 2012) due to violations of the State's water quality standard for DO and pH. All nontidal tributaries of Thompson Creek were added to the impairment on Virginia's 2012 Integrated Report.

DEQ monitored 2 stations on Thompson Creek and tributaries with dates ranging from July 2000 through March 2011. Of the 27 total pH data points recorded, 23 violated water quality standards for pH (85%), and 8 of 27 DO data points violated the water quality standards for DO concentration (30%). The pH minimum and maximum values ranged from 4.3 to 6.8 S.U., and DO values ranged from 0.99 to 12.64 mg/L. Both stations violated the pH and DO water quality standards more than 10.5% of samples. Figures E1 and E2 show DO and pH concentrations at the listing station 1ATHP001.15.

Figure E1. Time series of DO at Thompson Br. station 1ATHP001.15, minus 7/10/2000, DO=1.62 mg/L.

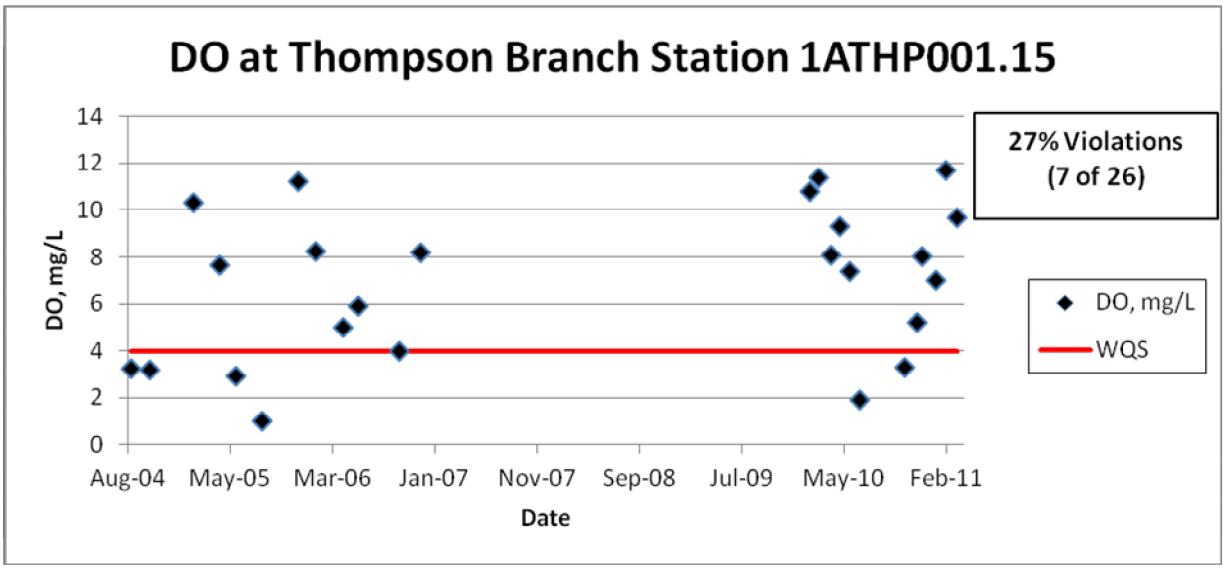
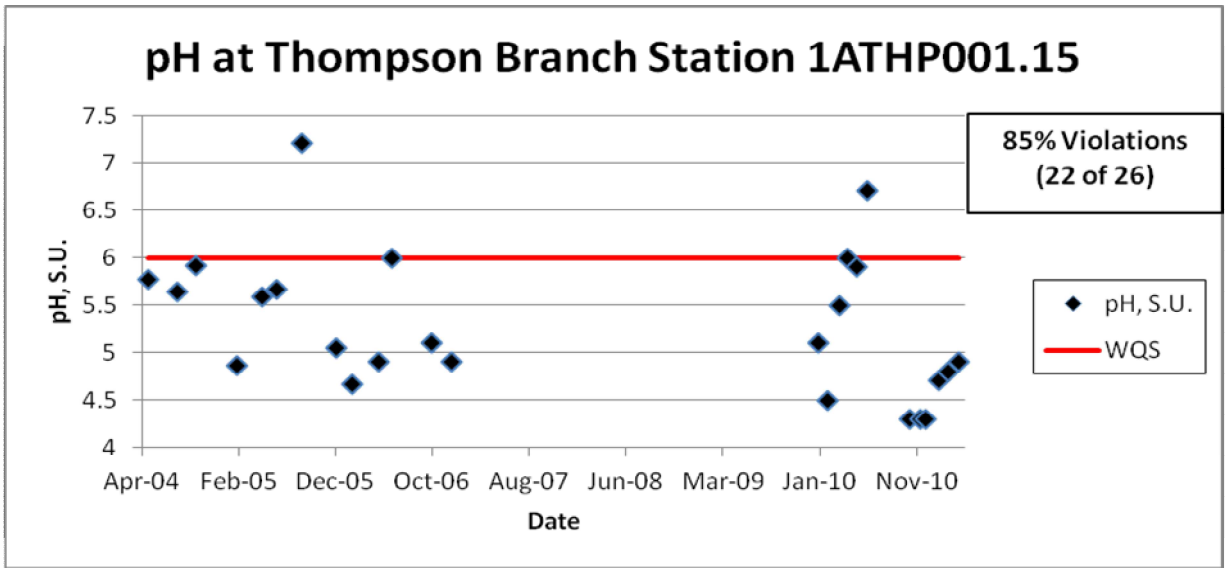


Figure E2. Time series of pH at Thompson Branch station 1ATHP001.15, minus 7/10/2000, pH=5.62 S.U.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, Thompson Creek and tributaries must support all designated uses and meet all applicable criteria. If the waterbody violates the instantaneous DO water quality standard of 4.0 mg/l or pH values are less than 6.0 or greater than 9.0 in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

In 2003 VADEQ proposed a methodology for determining whether low DO or pH originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia" (MapTech 2003).

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of swamps or wetlands. These conditions often also produce low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or low pH levels and for determining the likelihood of anthropogenic impacts is described below. DEQ staff use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure, all DO and pH data should be screened for flows less than the 7Q10. DO and pH data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

There were no dates with DO and pH data collected at 1ATHP001.15, when flows were estimated to be less than 7Q10 from the drainage area comparison with Piscataway Branch.

The percent slope of Thompson Creek and tributaries ranged from 0.34% to 0.35% slope. These were below the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swampy areas and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

The VADEQ collected nutrient data from the original listing station 1ATHP001.15 (May 2004 to March 2011, Table 6). The average nitrate and total phosphorus (TP) were below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas with levels of nitrate < 0.6 mg/l and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact. The average total nitrogen (TN) of 1.283 mg/l was 28 percent above the USGS (1999) background TN value of 1.0 mg/l. There are no permitted dischargers in the Thompson Branch and tributaries watershed. There is a moderate amount of agricultural land use in the Thompson Branch watershed (~30%), most of which is located along Cople Road (Route 202), in the southernmost part of the watershed farthest in the watershed from the sampling station. The urban land use exists sparsely only along the roadways, totaling approximately 29 homes and 2 commercial entities upstream of the sampling station. Only approximately half of these are within one mile upstream of the station. Also on one sample date, June 16, 2010, abnormally high Total Kjeldahl nitrogen (TKN of 8.2 mg/L) and TP of 0.67 mg/L were found. This almost always occurs during very high storm runoff, however flow was noted to be very low on this date. While these concentrations were elevated, the low flow means that the nutrient load to the watershed on this date was very low. There appears to be slight anthropogenic impact upon the sampling station, therefore this TN was considered to be of primarily natural origin and not sufficient reason to preclude natural Class VII designation.

Thompson Branch exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no active permitted point source dischargers in the Thompson Branch and tributaries watershed. The watershed is approximately 1817 acres (2.84 mi^2) in size. The watershed is predominately wetlands (32 percent) and forested (30.0%). Agriculture (hay/pasture 8 percent and cropland 22 percent) comprises 30 percent of the watershed. Urban areas compose approximately 6 percent of the land base. The remaining 2 percent of the watershed is comprised of other grasses. Per most recent aerial photography there are approximately 29 homes and two commercial properties in the portion of the watershed upstream of the sampling station. Land use was not considered to have significantly impacted the swampwater conditions of Thompson Branch and tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Thompson Branch and tributaries located in waterbody identification codes (WBID) VAP-A32R. This obviates the need for a future DO and pH TMDL for the watershed.

DEQ performed the assessment of the Thompson Branch and tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Thompson Branch and tributaries are located within Westmoreland County, Virginia, and are minor tributaries of the Lower Machodoc Creek, a major tributary of the Potomac River. There are 3.91 total stream miles in the Thompson Branch watershed (National Hydrography Dataset (NHD)) using GIS. Thompson Branch is fed by two unnamed tributaries (UT). The impaired segment for low dissolved oxygen (DO) and pH in Thompson Branch and tributaries totals 1.65 miles. Thompson Branch and tributaries generally flow east from their headwaters east of Mount Holly, VA, to Lower Machodoc Creek and the Potomac River.

2. Physical Settings

2.1. Listed Water Bodies

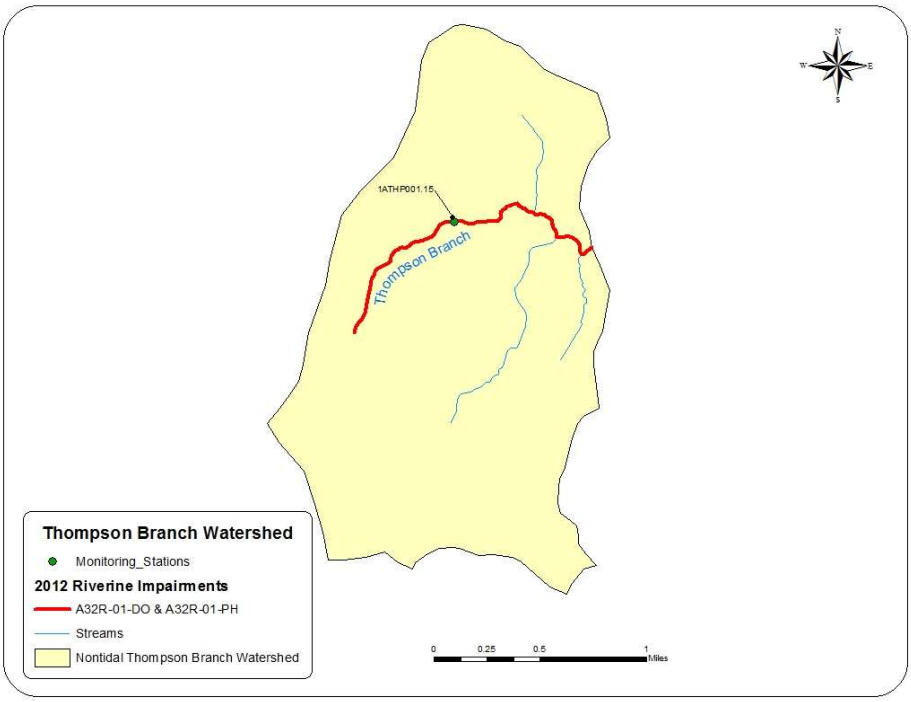
The mainstem of nontidal Thompson Branch was listed as impaired on Virginia's 2006, 2008, 2010 and 2012 305(b) / 303(d) Integrated Reports (VADEQ, 2006, 2008, 2010 and 2012) due to violations of the State's water quality standard for DO and pH. All nontidal tributaries of Thompson Branch were added to the impairment on Virginia's 2012 Integrated Report. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The waterbody identification code (WBID, Virginia Hydrologic Unit) for non-tidal Thompson Branch is VAP-A32R.

2.2. Watershed

2.2.1. General Description

Thompson Branch and tributaries generally flow east from the headwaters east of Mount Holly, VA, to the Lower Machodoc Creek and the Potomac River. The watershed totals approximately 2.84 mi^2. There is no continuous flow gaging station on Thompson Branch and tributaries. See Figure 1 for a map of the watershed including one monitoring station.

Figure 1. The Thompson Branch watershed map and associated monitoring station.



2.2.2. Geology, Climate, Land Use

Geology and Soils

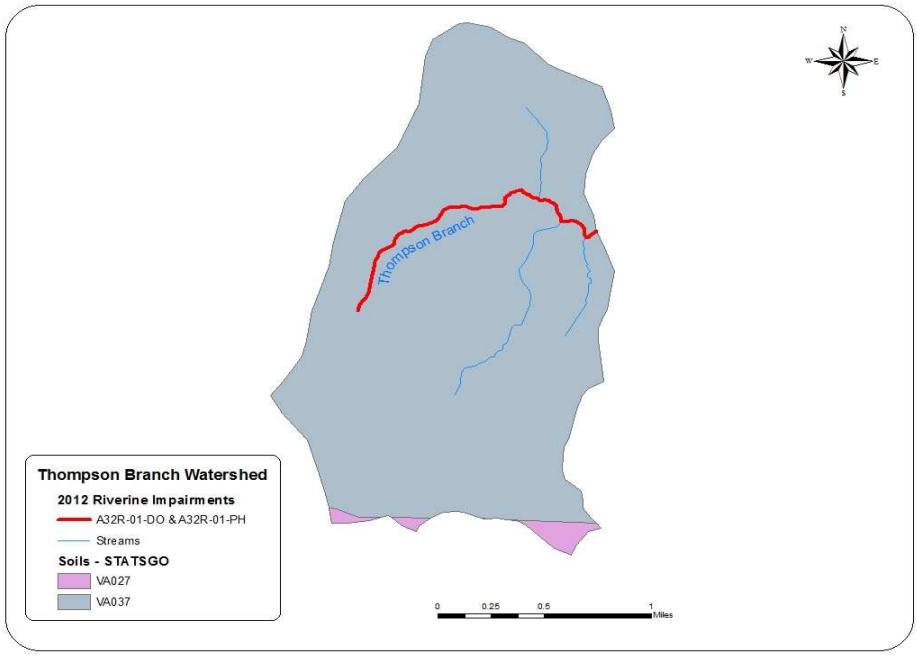
The impaired segment of Thompson Branch and tributaries is within the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf).

Soils for the Thompson Branch and tributaries watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://soils.usda.gov/technical/classification/osd/index.html). Figure 2 shows the location of these general soil types in the watershed.

Soils of the **Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027)** series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow permeability. They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

The **Portsmouth - Roanoke -Rains - Eunola - Levy - Kalmia Series (VA037)** are very deep, very poorly to moderately well drained soils. These soils are located on low stream or marine terraces and in marshes of the Atlantic Coastal Plain. These series are formed from fluvial and marine sediments. Permeability of these soil types ranges from very slow to rapid, depending on soil composition.

Figure 2. Soil Characteristics of the Thompson Branch and tributaries Watershed.



Climate

The climate summary for Thompson Branch and tributaries comes from a weather station located in Warsaw, VA (448894) with a period of record from 1893 to 2012. The average annual maximum and minimum temperatures (°F) at the weather station are 68.3 and 46.6 and the annual rainfall (inches) is 42.53 (Table 1) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 1. Climate summary for Warsaw, Virginia (448894).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	47.2	49.1	58.4	68.7	77.4	84.7	88.0	86.6	80.7	70.6	59.8	49.3	68.3
Average Min. Temperature (F)	27.4	28.4	35.6	44.3	53.8	62.6	66.7	65.7	59.1	47.7	38.4	30.1	46.6
Average Total Precipitation (in.)	3.10	2.81	3.73	3.11	3.76	3.82	4.44	4.58	3.77	3.27	3.00	3.14	42.53

Land Use

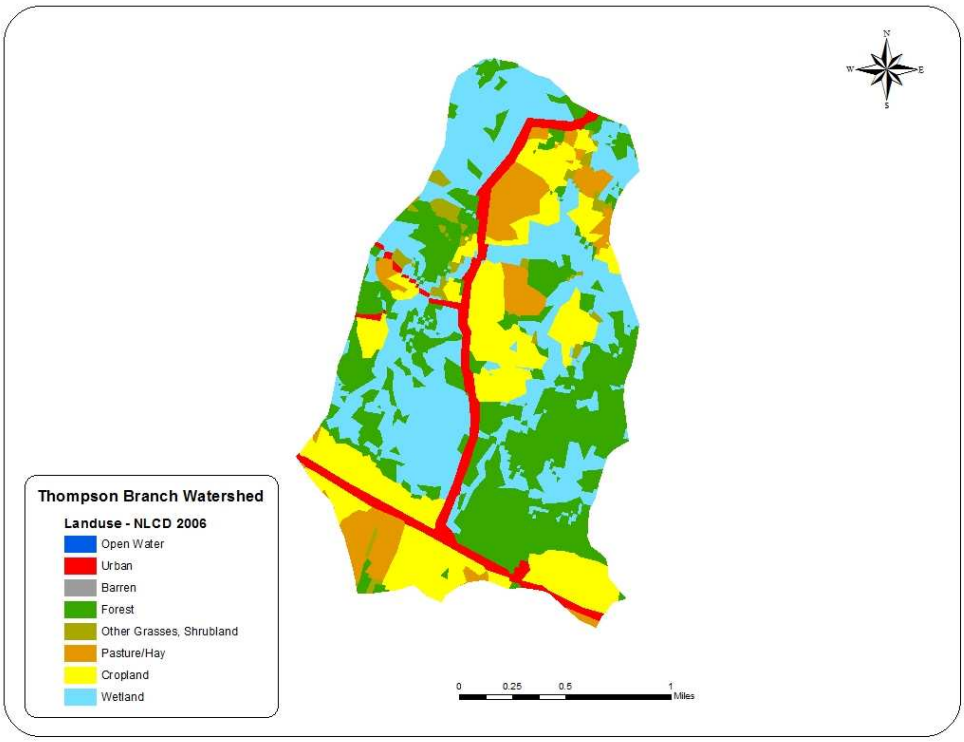
The Thompson Branch and tributaries watershed extends approximately from Erica, VA south to Machodoc, VA, and west to Mount Holly, VA. It is approximately 3 miles long and one mile wide. The watershed is approximately 1817 acres (2.84 mi^2) in size and is predominately wetlands (32 percent) and forested (30.0%). Agriculture (hay/pasture 8 percent and cropland 22 percent) comprises 30 percent of the watershed. Urban areas compose approximately 6 percent of the land base. The remaining 2 percent of the watershed is comprised of other grasses. Land use acres and percentages were affected by rounding. Land use is described in Table 2.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land use is concentrated along US. Rt. 202 (Cople Highway) and country roads 626 and 665. Wetlands are located all along Thompson Branch within the watershed, which generally flows west to east.

Table 2. Land Use in the Thompson Branch Watershed

Land Use Type	Acres	Square Miles	Percent
Open Water	0	0	0
Urban	108.8	0.17	6.0%
Barren	0	0	0.0%
Forest	544	0.85	30.0%
Pasture/Hay	147.2	0.23	8.2%
Cropland	390.4	0.61	22%
Other Grasses	44.8	0.07	2.3%
Wetland	582.4	0.91	32.0%
Totals:	**1817.6**	**2.84**	**100%**
Land Use Type	**Acres**	**Square Miles**	**Percent**

Figure 3. Land Use in the Thompson Branch and tributaries Watershed



3. Description of Water Quality Problem/Impairment

The mainstem of nontidal Thompson Branch was listed as impaired on Virginia's 2006, 2008, 2010 and 2012 305(b) / 303(d) Integrated Reports (VADEQ, 2006, 2008, 2010 and 2012) due to violations of the State's water quality standard for DO and pH. All nontidal tributaries of Thompson Branch were added to the impairment on Virginia's 2012 Integrated Report. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ monitored 2 stations on Thompson Branch and tributaries (see Figure 1) with dates ranging from July 2000 through March 2011. Of the 27 total pH data points recorded, 23 violated water quality standards for pH (85%), and 8 of 27 DO data points violated the water quality standards for DO concentration (30%). The pH minimum and maximum values ranged from 4.3 to 6.8 S.U., and DO values ranged from 0.99 to 12.64 mg/L. Both stations violated the pH and DO water quality standards more than 10.5% of samples. The results are summarized in Table 3.

Table 3. pH and DO data collected by DEQ from 2 stations on Thompson Branch and tributaries.

		Number of Samples		SU		mg/l		Number of Violations	
Station	Sample Period	pH	DO	Average pH	Min-Max pH	Average DO	Min-Max DO	pH	DO
1ATHP001.15	July 10, 2000 to March 28, 2011	26	26	5.30	4.3 – 7.2	6.57	0.99 – 11.7	22	7
1ATHPRT665	7/10/2000	1	1	5.54	5.54	2.41	2.41	1	1

Time series graphs of all DO and pH data collected at the original listing station, Thompson Branch at station 1ATHP001.15, shows the DO ranged from 0.99 to 11.70 mg/L and the pH ranging from 4.3-7.2 S.U. (Figure 4 and Figure 5) respectively. The horizontal red line at the DO = 4.0 mark represents the minimum water quality standard in Figure 4. The data points below the DO = 4.0 line are violations of the water quality standard in Figure 4. The horizontal red line at the pH = 6.0 mark represents the minimum water quality standard in Figure 5. The data points below the pH = 6.0 line are violations of the water quality standard in Figure 5.

Figure 4. Time series of DO at Thompson Br. station 1ATHP001.15, minus 7/10/2000, DO=1.62 mg/L.

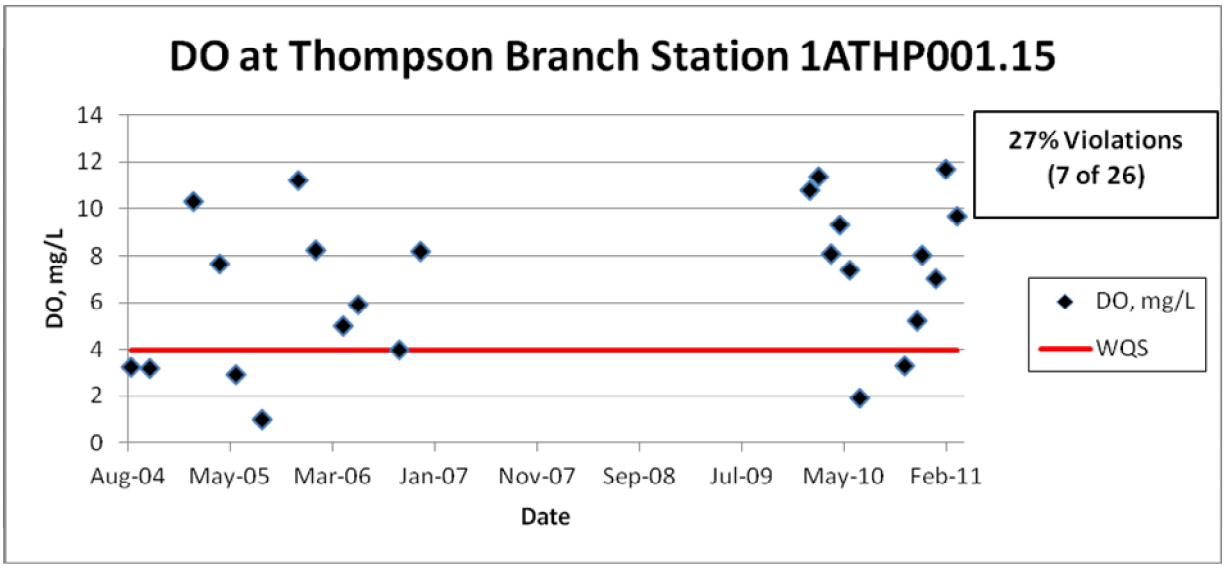
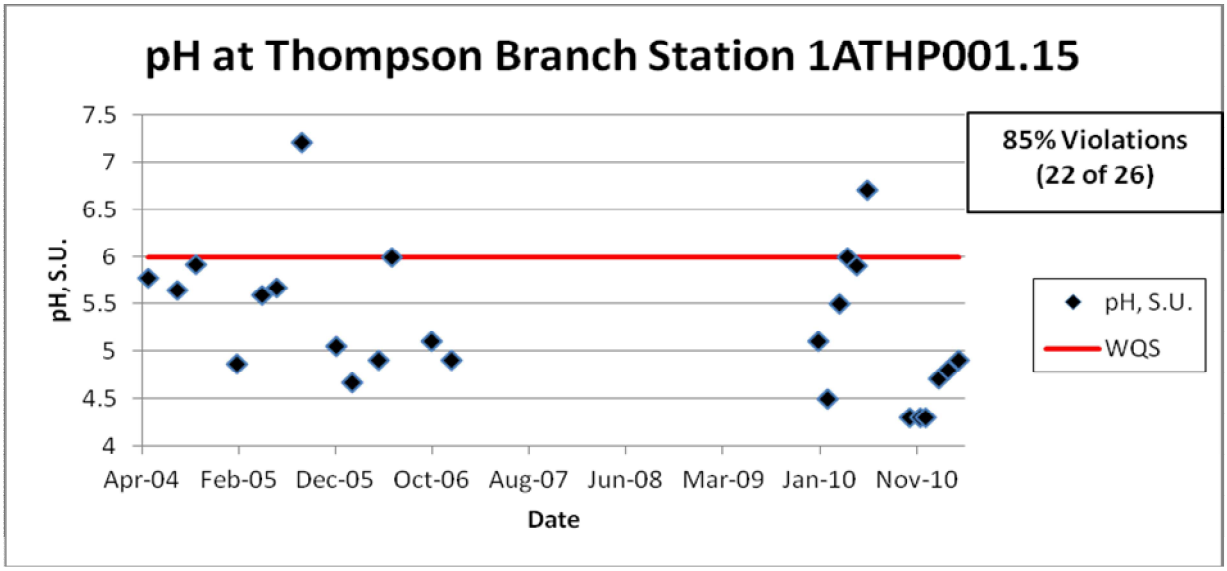


Figure 5. Time series of pH at Thompson Branch station 1ATHP001.15, minus 7/10/2000, pH=5.62 S.U.



3.1. Associated pH and DO of Thompson Branch and Tributaries

DEQ also monitored DO and pH data at one other station on Thompson Branch and tributaries for the assessment of low DO and pH due to the natural conditions. This station was located at Route 665, and was monitored only one time as a background site in conjunction with a sludge application. The single field reading for this station exceeded the water quality standards for both low DO and pH.

4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Thompson Branch must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO and pH in the Thompson Branch watershed are an instantaneous minimum DO of 4.0 mg/l and pH from 6.0 SU to 9.0 SU, as in Table 4.

Table 4. Applicable water quality standards

Parameter	Minimum, mg/l	Maximum, mg/l
pH	6.0	9.0
DO	4.0	-

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak

seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Branch, White Oak Swamp, Matadequin Branch and Mechumps Branch (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Branch, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy Rivers.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- average (= assessment period mean) nitrate less than 0.6 mg/L
- average total nitrogen (TN) less than 1.0 mg/L, and
- average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flow for Thompson Branch may be estimated by a drainage area ratio of the Thompson Branch watershed (2.84 mi^2) with the 7Q10 flow at the long-term continuous gaging station Piscataway Creek near Tappahannock, VA, (USGS:01669000), with a drainage area of 28.0 mi^2 and a 7Q10 of 0.50 cfs (2005). Thus the 7Q10 of Thompson Branch is estimated at 0.05 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

There were no dates with DO and pH data collected at 1ATHP001.15, when flows were estimated to be less than 7Q10 from the drainage area comparison with Piscataway Creek.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

The percent slope of Thompson Branch and tributaries ranged from 0.34% to 0.35% slope (Table 5). These were below the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swampy areas and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

Table 5. Calculated percent slopes for Thompson Branch and tributaries.

Stream	% Slope	Upstream Elevation (Feet) at Rivermile (RM)	Downstream Elevation (Feet) at Rivermile (RM)
Thompson Branch	0.35	20’ at RM 1.92	5.0’ at RM 1.11
UT Thompson Branch	0.34	25’ at RM 1.30	5.0’ at RM 0.19

Visual inspection of Thompson Branch and tributaries revealed swampy areas and heavy tree canopy in large swamp segments. Decomposition of vegetative matter from large swampy areas lowers DO and pH as decay occurs (Figures 6 and 7).

Figure 6. **Thompson Branch, Rt. 626, 1ATHP001.15, Downstream.**

Figure 7. **Thompson Branch, Rt. 665, Upstream.**

5.3 Instream Nutrients

The VADEQ collected nutrient data from the original listing station 1ATHP001.15 (May 2004 to March 2011, Table 6). The average nitrate and total phosphorus (TP) were below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas with levels of nitrate < 0.6 mg/l and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact. The average total nitrogen (TN) of 1.283 mg/l was 28 percent above the USGS (1999) background TN value of 1.0 mg/l. Organic nitrogen comprised 68 percent of the total nitrogen, with nitrate 25 percent, nitrite < 1 percent and ammonia 7 percent. There are no permitted dischargers in the Thompson Branch and tributaries watershed. There is a moderate amount of agricultural land use in the Thompson Branch watershed (~30%), most of which is located along Cople Road (Route 202), in the southernmost part of the watershed (Figure 3) farthest in the watershed from the sampling station. The urban land use exists sparsely only along the roadways (Figure 3), totaling approximately 29 homes and 2 commercial entities upstream of the sampling station. Only approximately half of these are within one mile upstream of the station. Also on one sample date, June 16, 2010, abnormally high Total Kjeldahl nitrogen (TKN of 8.2 mg/L) and TP of 0.67 mg/L were found. This almost always occurs during very high storm runoff events, however flow was noted to be very low on this date. While these concentrations were elevated, the low flow means that the nutrient load to the watershed on this date was very low. Without these very low flow TKN and TP values, the average TN would be 1.005 mg/l and the average TP would be 0.068 mg/L. There appears to be slight anthropogenic impact upon the sampling station, therefore this TN was considered to be of primarily natural origin and not sufficient reason to preclude natural Class VII designation.

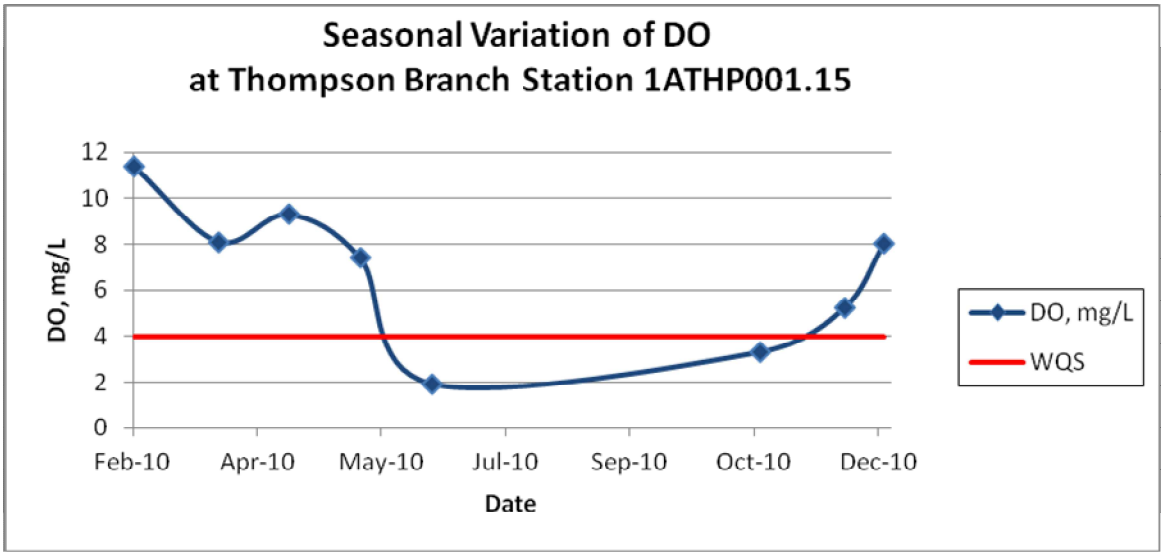
Table 6. Instream Nutrients of Thompson Branch Station 1ATHP001.15

Parameter	Average Conc.	Number
Total Phosphorus	**0.091 mg/l**	(n=26)
Orthophosphorus	0.018 mg/l	(n=12)
Total Kjeldahl Nitrogen	0.963 mg/l	(n=26)
Ammonia as N	0.093 mg/l	(n=26)
Nitrate as N	**0.327 mg/l**	(n=12)
Nitrite as N	0.006 mg/l	(n=12)
TN (TKN + NO_3 + NO_2)	**1.283 mg/l**	(n=26)
Nitrite + Nitrate, Total as N	0.320 mg/l	(n=26)

5.4 Natural Seasonal DO Fluctuation

The 2010 DO data collected at the Thompson Branch station 1ATHP001.15 were graphed to demonstrate the natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 8.

Figure 8. Seasonal DO Variation at Thompson Branch at Rt. 626, February to December 2010.



5.5 Impact from Point Source Dischargers and Land Use

There are no active permitted point source dischargers in the Thompson Branch and tributaries watershed. The watershed is approximately 1817 acres (2.84 mi^2) in size and is predominately wetlands (32 percent) and forested (30.0%). Agriculture (hay/pasture 8 percent and cropland 22 percent) comprises 30 percent of the watershed. Urban areas compose approximately 6 percent of the land base. The remaining 2 percent of the watershed is comprised of other grasses. Per most recent aerial photography there are approximately approximately 29 homes and two commercial properties in the portion of the watershed upstream of the sampling station. Land use was not considered to have significantly impacted the swampwater conditions of Thompson Branch and tributaries.

6. CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background
- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

There were no dates with DO and pH data collected at 1ATHP001.15, when flows were estimated to be less than 7Q10 from the drainage area comparison with Piscataway Branch.

The percent slope of Thompson Branch and tributaries ranged from 0.34% to 0.35% slope (Table 5). These were below the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swampy areas and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

The VADEQ collected nutrient data from the original listing station 1ATHP001.15 (May 2004 to March 2011, Table 6). The average nitrate and total phosphorus (TP) were below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas with levels of nitrate < 0.6 mg/l and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact. The average total nitrogen (TN) of 1.283 mg/l was 28 percent above the USGS (1999) background TN value of 1.0 mg/l. Organic nitrogen comprised 72 percent of the total nitrogen, with nitrate 21 percent, nitrite < 1 percent and ammonia 6 percent. There are no permitted dischargers in the Thompson Branch and tributaries watershed. There is a moderate amount of agricultural land use in the Thompson Branch watershed (~30%), most of which is located along Cople Road (Route 202), in the southernmost part of the watershed (Figure 3) farthest in the watershed from the sampling station. The urban land use exists sparsely only along the roadways (Figure 3), totaling approximately 29 homes and 2 commercial entities upstream of the sampling station. Only approximately half of these are within one mile upstream of the station. Also on one sample date, June 16, 2010, abnormally high Total Kjeldahl nitrogen (TKN of 8.2 mg/L) and TP of 0.67 mg/L were found. This almost always occurs during very high storm runoff events, however flow was noted to be very low on this date. While these concentrations were elevated, the low flow means that the nutrient load to the watershed on this date was very low. Without these very low flow TKN and TP values, the average TN would be 1.005 mg/l and the average TP would be 0.068 mg/L. There appears to be slight anthropogenic impact upon the sampling station, therefore this TN was considered to be of primarily natural origin and not sufficient reason to preclude natural Class VII designation.

Thompson Branch exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no active permitted point source dischargers in the Thompson Branch and tributaries watershed. The watershed is approximately 1817 acres (2.84 mi^2) in size and is predominately wetlands (32 percent) and forested (30.0%). Agriculture (hay/pasture 8 percent and cropland 22 percent) comprises 30 percent of the watershed. Urban areas compose approximately 6 percent of the land base. The remaining 2 percent of the watershed is comprised of other grasses. Per most recent aerial photography there are approximately approximately 29 homes and two commercial properties in the portion of the watershed upstream of the sampling station. Land use was not considered to have significantly impacted the swampwater conditions of Thompson Branch and tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Thompson Branch and tributaries located in waterbody identification codes (WBID) VAP-A32R. This obviates the need for a future DO and pH TMDL for the watershed.

DEQ performed the assessment of the Thompson Branch and tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

7. References

Maptech, Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia. 2003.

NRCS (Natural Resource Conservation Service) http://soils.usda.gov/technical/classification/osd/index.html (Accessed 09/04/2008)

SRCC (Southeast Regional Climate Center)
http://www.dnr.state.sc.us/climate/sercc/products/historical/historical_va.html
(Accessed 12/18/02)

USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADCR (Virginia Department of Conservation and recreation)
http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf
(Accessed 09/04/2008)

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 2006. Virginia. 2002.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 2008. Virginia. 2006.

VADEQ (Virginia Department of Environmental Quality), Virginia Integrated Report 2010. Virginia. 2010.

VADEQ (Virginia Department of Environmental Quality), Virginia Integrated Report 2012. Draft. Virginia. 2012.